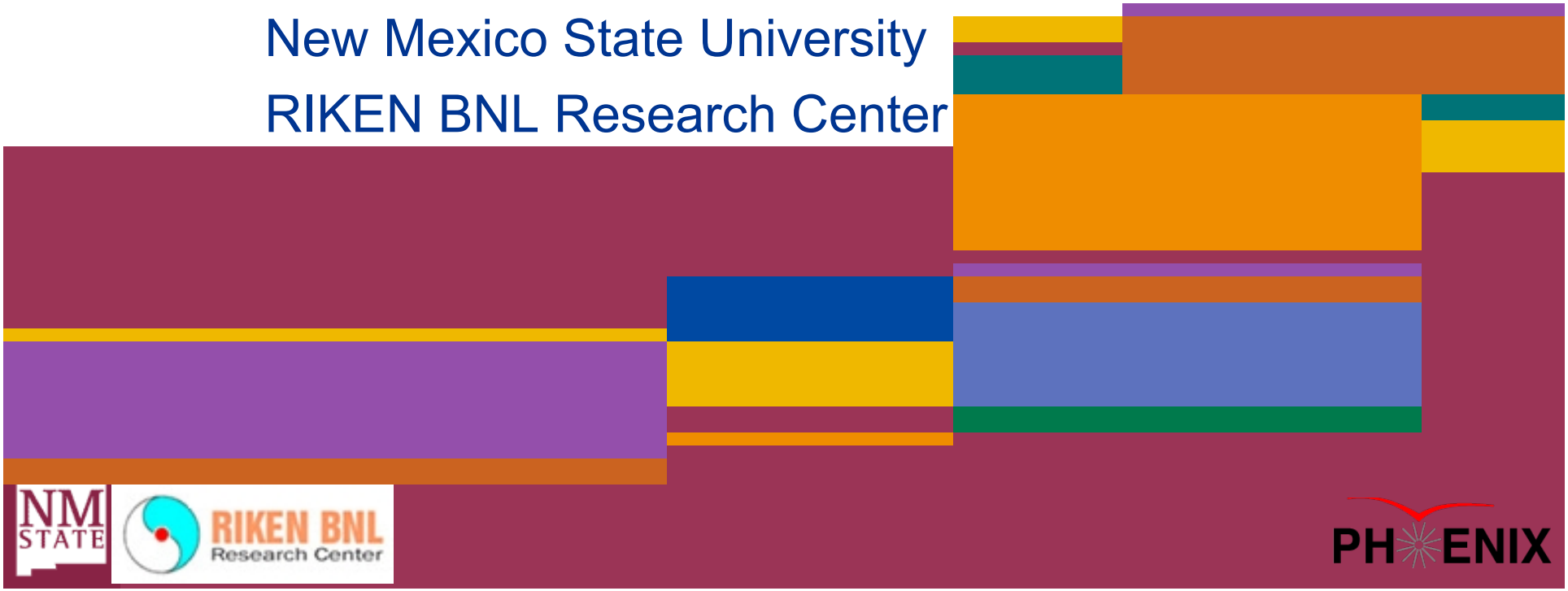
Accessing the sea quark polarization via *W* measurements at PHENIX

Xiaorong Wang for PHENIX collaboration

New Mexico State University

RIKEN BNL Research Center



Proton Spin 1/2: Crisis behind one half

Know very little

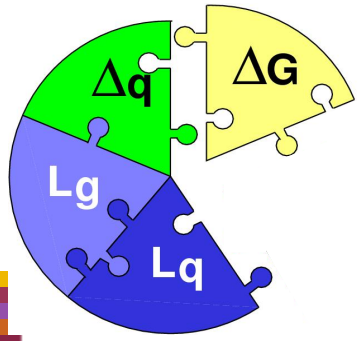
$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + \Delta L_q + \Delta L_g$$

~0.33 (small)

Poorly constrained

$$\Delta\Sigma = \Delta u + \Delta d + \Delta\bar{u} + \Delta\bar{d} + \ldots$$

Poorly constrained



RHIC Spin Program

- Longitudinal spin program

-- Gluon polarization distribution

$$\Delta G = \int_0^1 dx \cdot \Delta g(x)$$

-- Anti-quark sea polarization

$$A_L(u + \bar{d} \rightarrow W^+ \rightarrow l^+ + \nu_l)$$

$$A_L(\bar{u} + d \rightarrow W^- \rightarrow l^- + \bar{\nu}_l)$$

- Transverse spin program

sensitivity to <Lz> + transversity

Polarized Parton Distribution Function

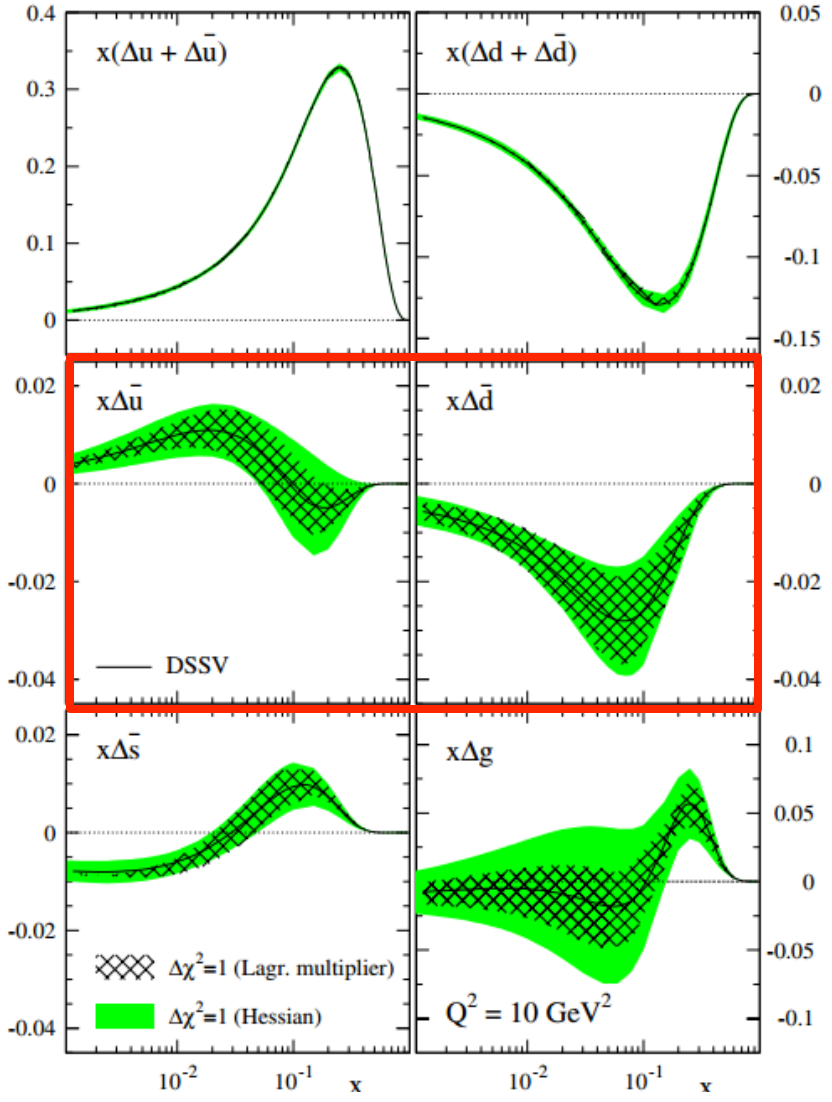
- 30 years of DIS/SIDIS measurements

Sensitive to quark antiquark sum

- Recent pp collisions at RHIC

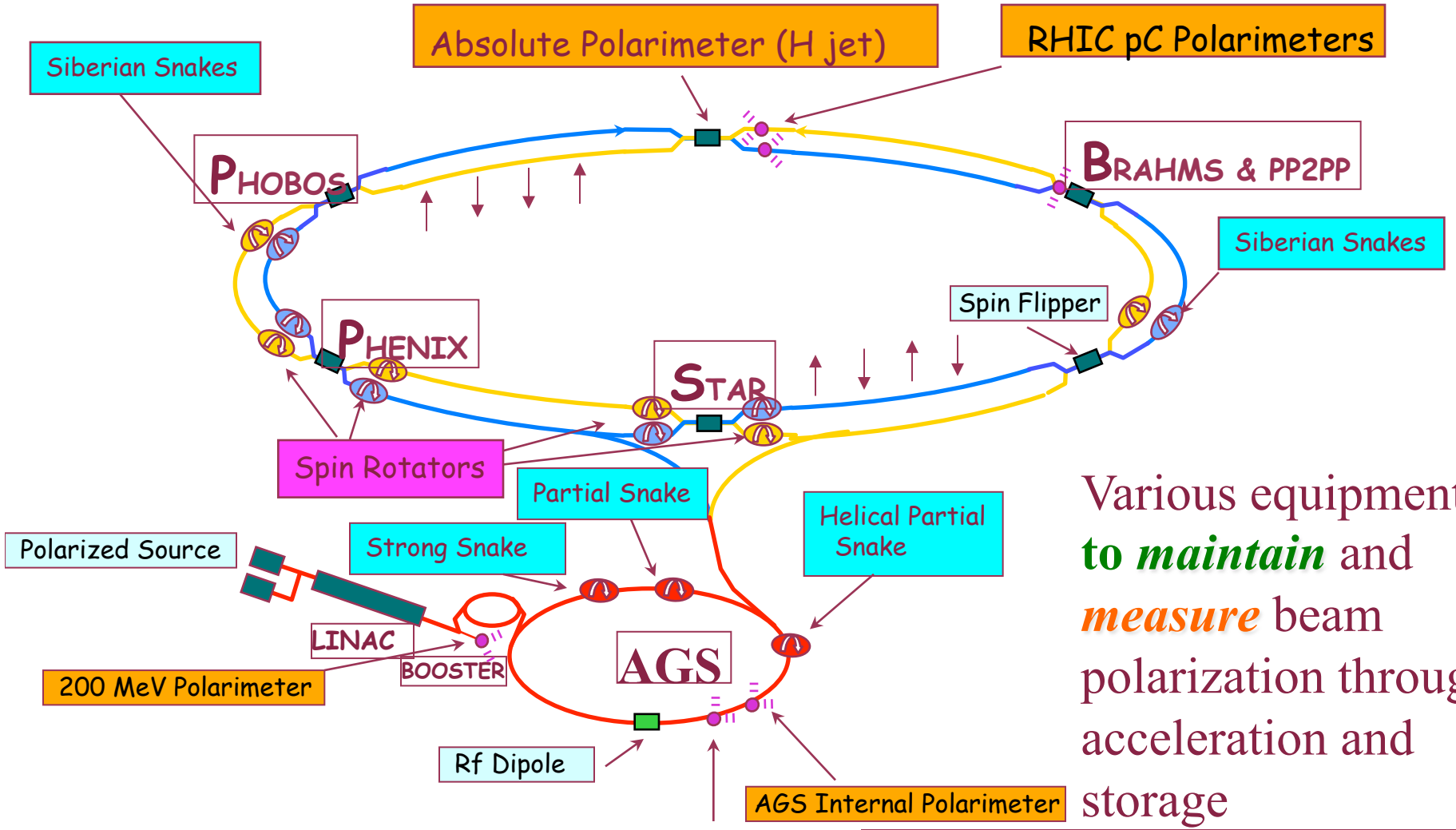
Constrain on gluon polarization

- W asymmetry measurement allow us to access sea quark contribution $\Delta\bar{u}$ and $\Delta\bar{d}$



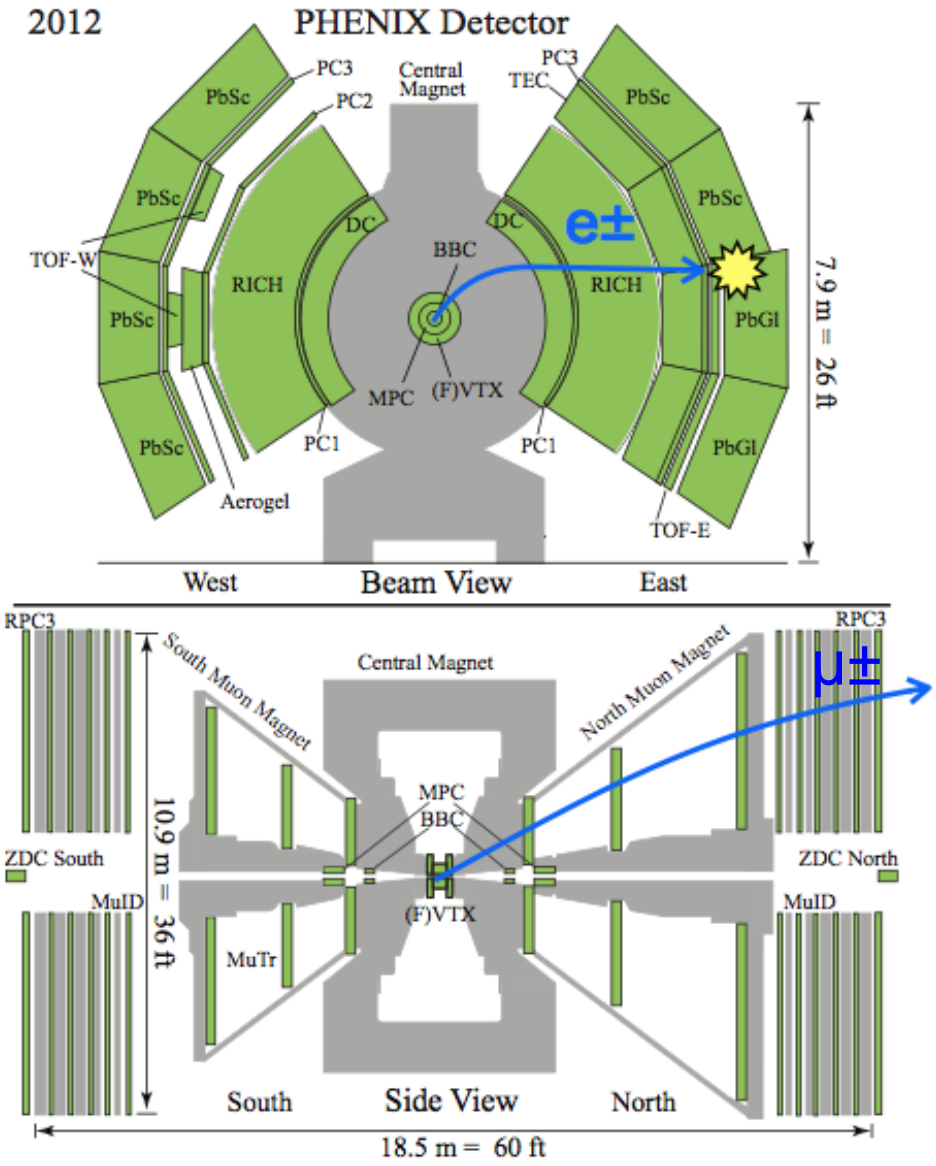
Phys. Rev. D 80, 034030 (2009)

RHIC as a Polarized p + p Collider



Various equipment **to *maintain*** and ***measure*** beam polarization through acceleration and storage

Measurement of W at PHENIX



Central Arms

$|\eta| < 0.35$

Trigger: EMCal + RICH ("ERT")

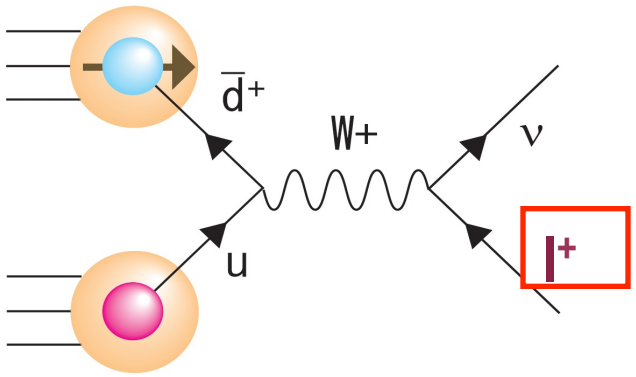
Detectors: DC, PC, EMCal

Muon Arms

$1.2 < |\eta| < 2.4$

Trigger: Small sagitta + MuID + timing (RPC/BBC)
Detectors: MuTr, MuID, RPC, BBC FVTX

Flavor-Separated Sea Quark at PHENIX

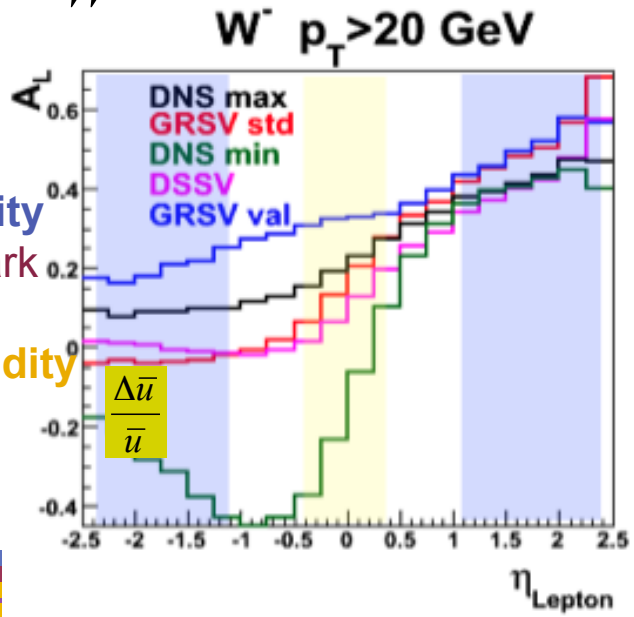


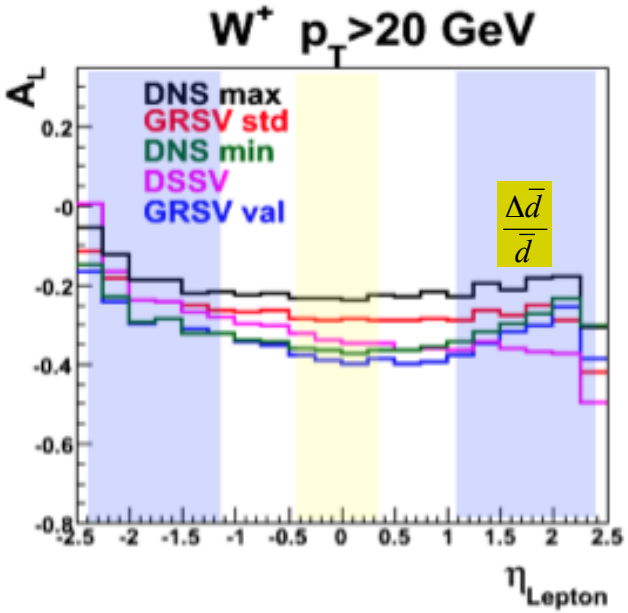
$$u + \bar{d} \rightarrow W^+ ; \bar{u} + d \rightarrow W^-$$

$$A_L^{W^+} \approx \frac{\Delta u(x_1)\bar{d}(x_2) - \Delta\bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)} \begin{cases} \langle x_1 \rangle >> \langle x_2 \rangle : A_L^{W^+} \approx -\dfrac{\Delta u}{u} \\ \langle x_1 \rangle << \langle x_2 \rangle : A_L^{W^+} \approx \dfrac{\Delta\bar{d}}{\bar{d}} \end{cases}$$

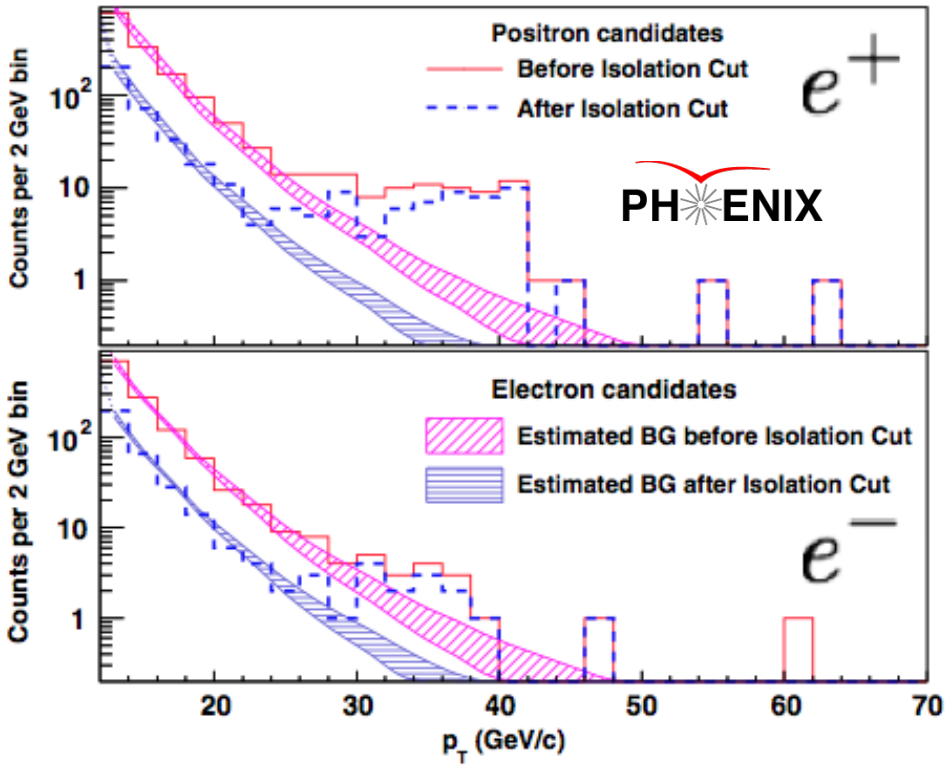
$$A_L^{W^-} \approx \frac{\Delta d(x_1)\bar{u}(x_2) - \Delta\bar{u}(x_1)d(x_2)}{d(x_1)\bar{u}(x_2) + \bar{u}(x_1)d(x_2)} \begin{cases} \langle x_1 \rangle >> \langle x_2 \rangle : A_L^{W^-} \approx \dfrac{\Delta d}{d} \\ \langle x_1 \rangle << \langle x_2 \rangle : A_L^{W^-} \approx \dfrac{\Delta\bar{u}}{\bar{u}} \end{cases}$$

PHENIX Muon Arm Rapidity
measuring the different quark flavor distributions
PHENIX Central Arm Rapidity
measuring the mixture or quark flavor contribution

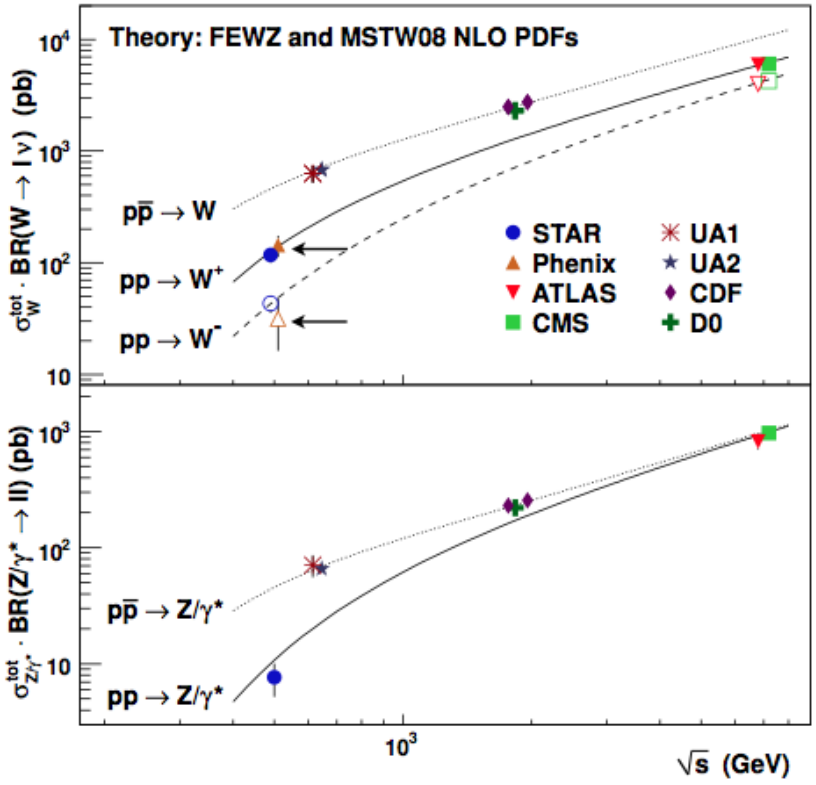




$W^{\pm} \rightarrow e^{\pm}$ Cross Section in Central Arm



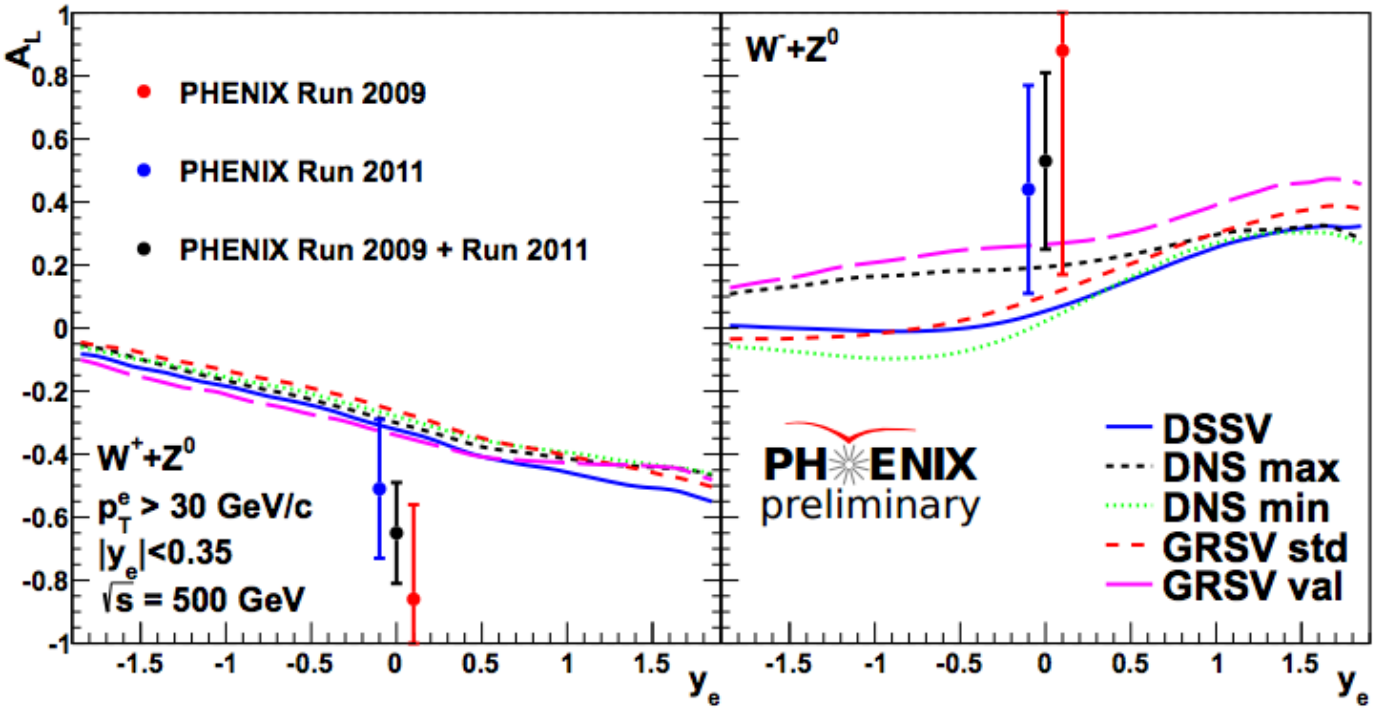
Phys. Rev. Lett. 106 (2011) 062001



Phys. Rev. D85 (2012) 092010

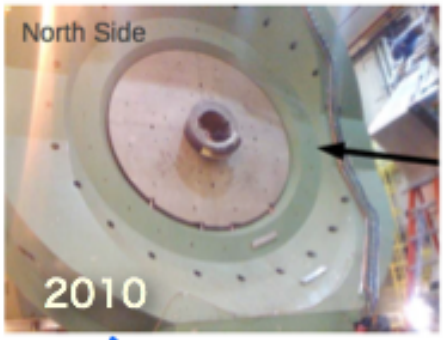
W cross sections for e decay channel from both PHENIX and STAR described well along with Tevatron and LHC data.

$W^{\pm} \rightarrow e^{\pm}$ A_L at Central Arm



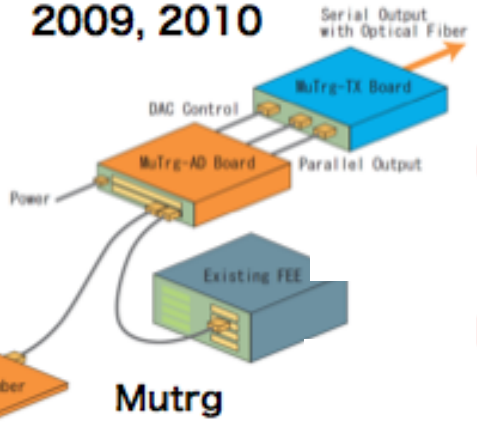
Run11 results are consistent with Run9 published data.
Consistent with global analyses predictions.

PHENIX Forward Upgrade Program

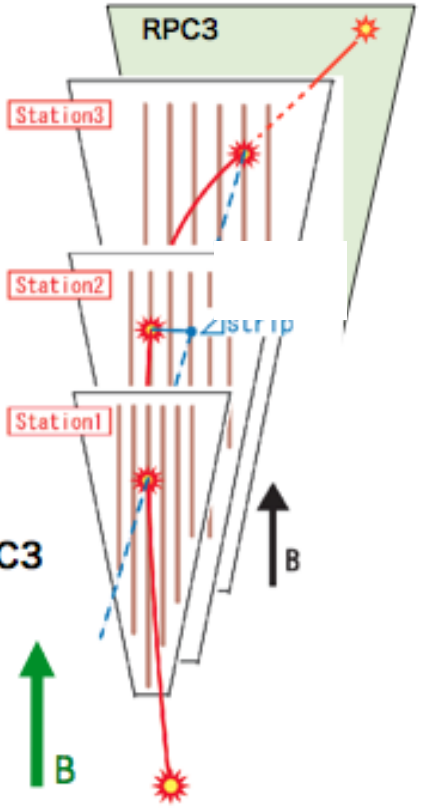


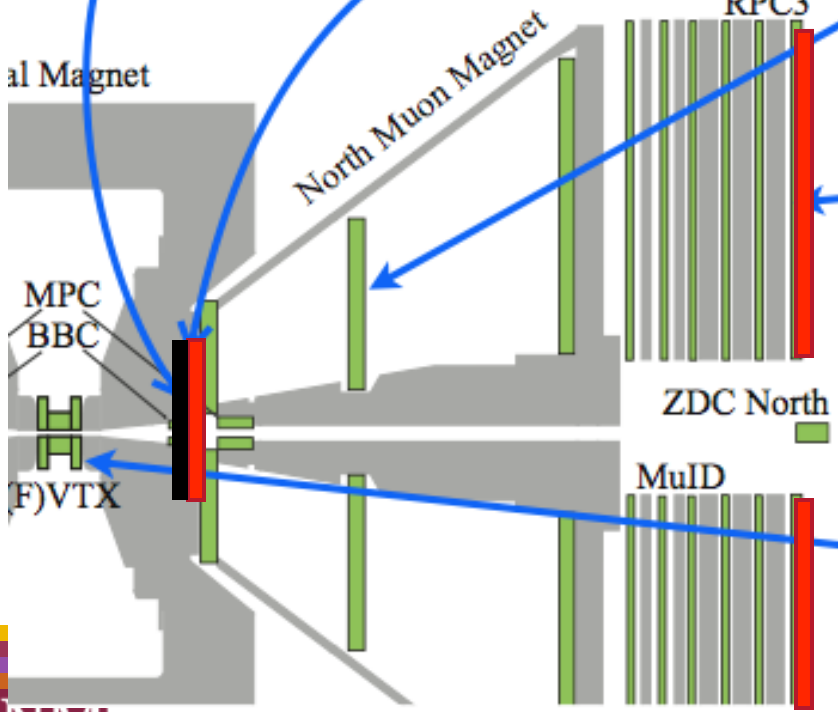
Absorber

RPC1

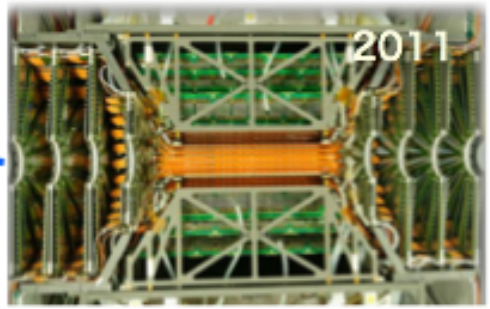


Mutrg





RPC3



FVTX

Single Muon Spectrum at Forward Rapidity

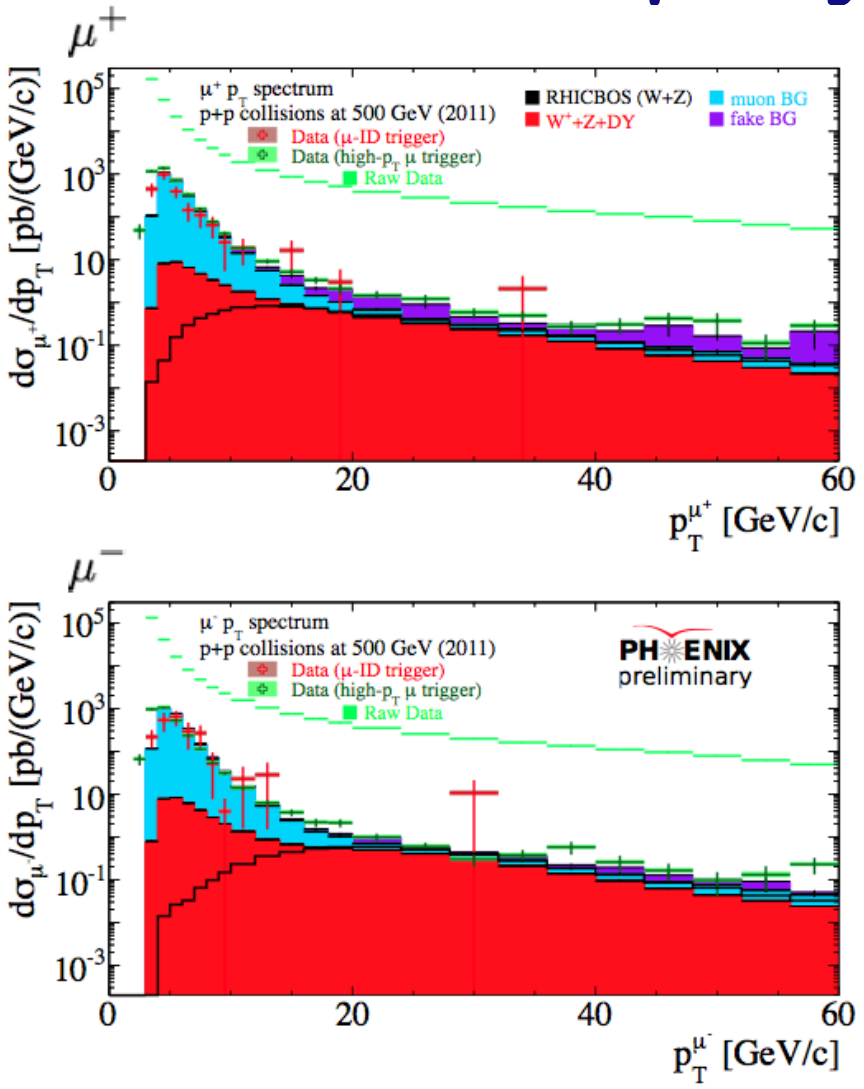
Data and simulated muon cross section

W→μ signal

Irreducible background

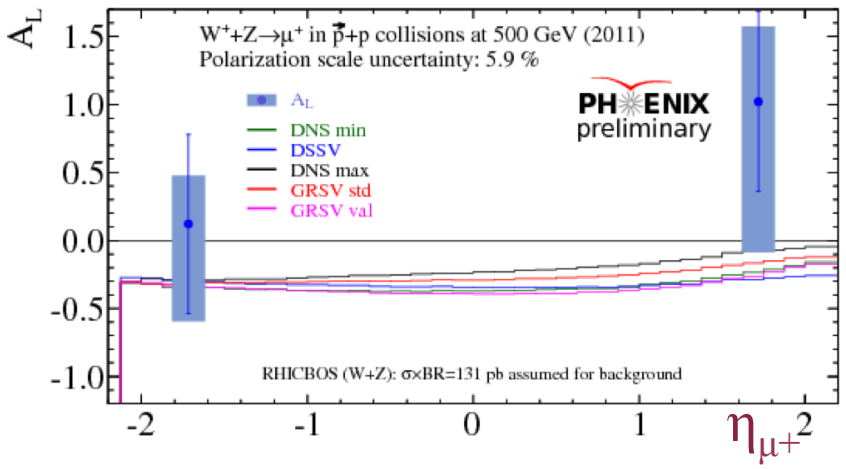
Fake background

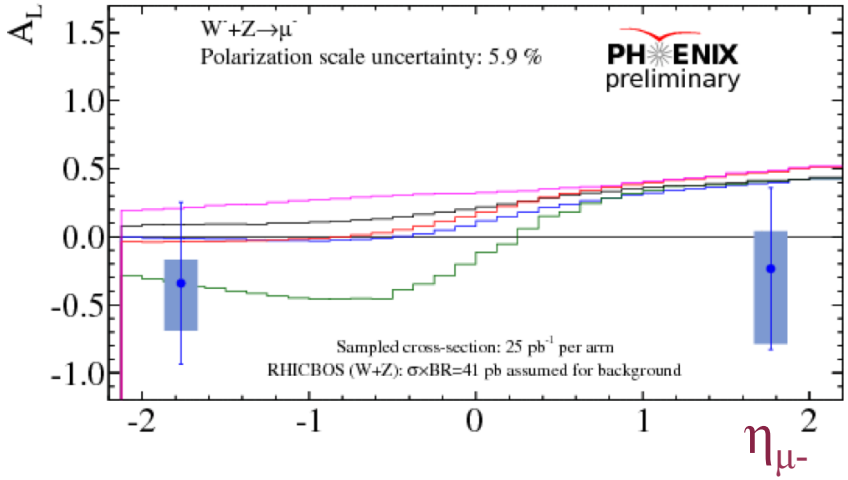
Signal to background ~1:3 (p_T > 15 GeV/*c*)



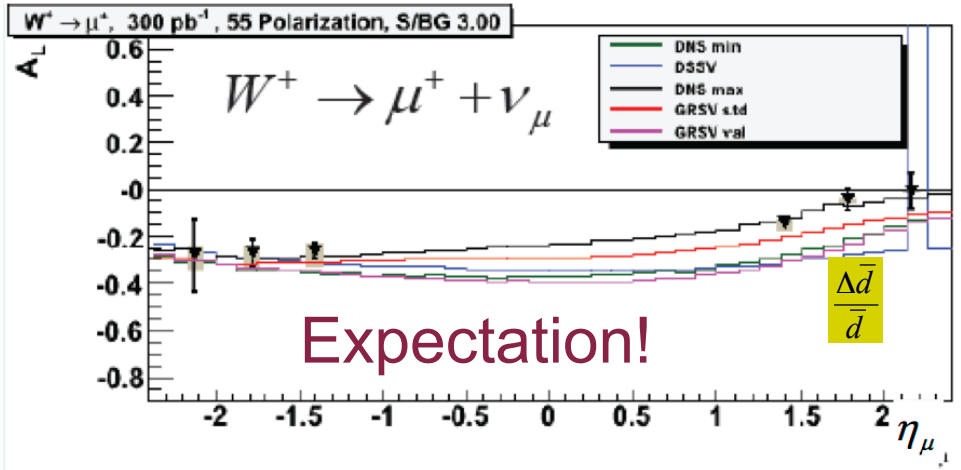
First $W^{\pm}\rightarrow\mu^{\pm}$ A_L at Forward Rapidity

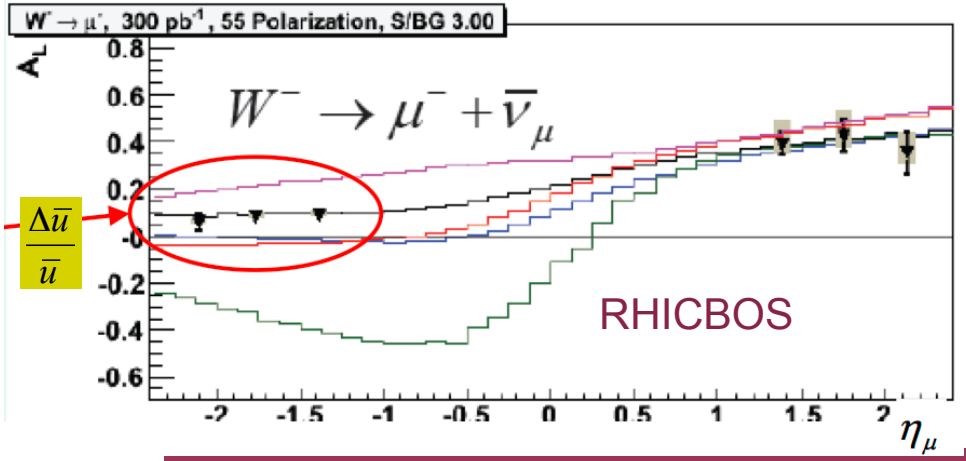
Run2011 L = 25.5 pb^{-1}/arm, P =50%





L = 300 pb^{-1}, P =55%, S/B =3.0

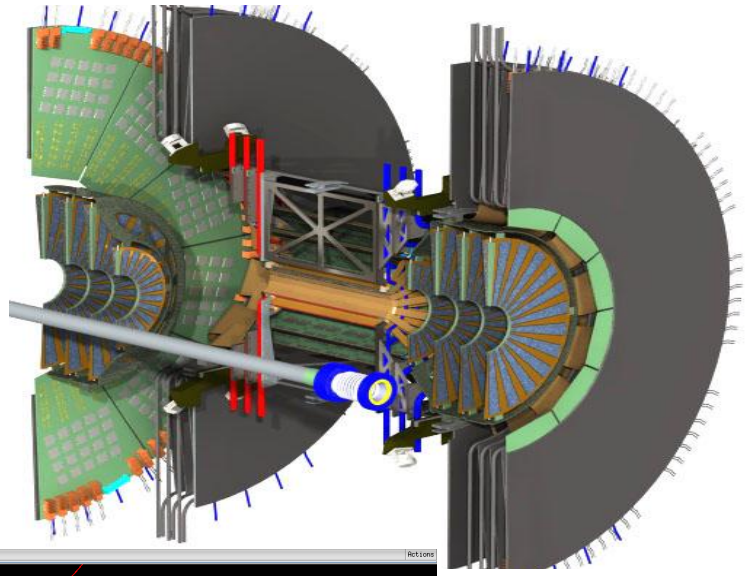




Expect FVTX to make contribution on background reduction!

FVTX Commissioning and Current Status

FVTX covers $1.2 < |\eta| < 2.4$, 2π in φ;
1.1 Million strips (each 75 μm radial, 3.75 in φ);

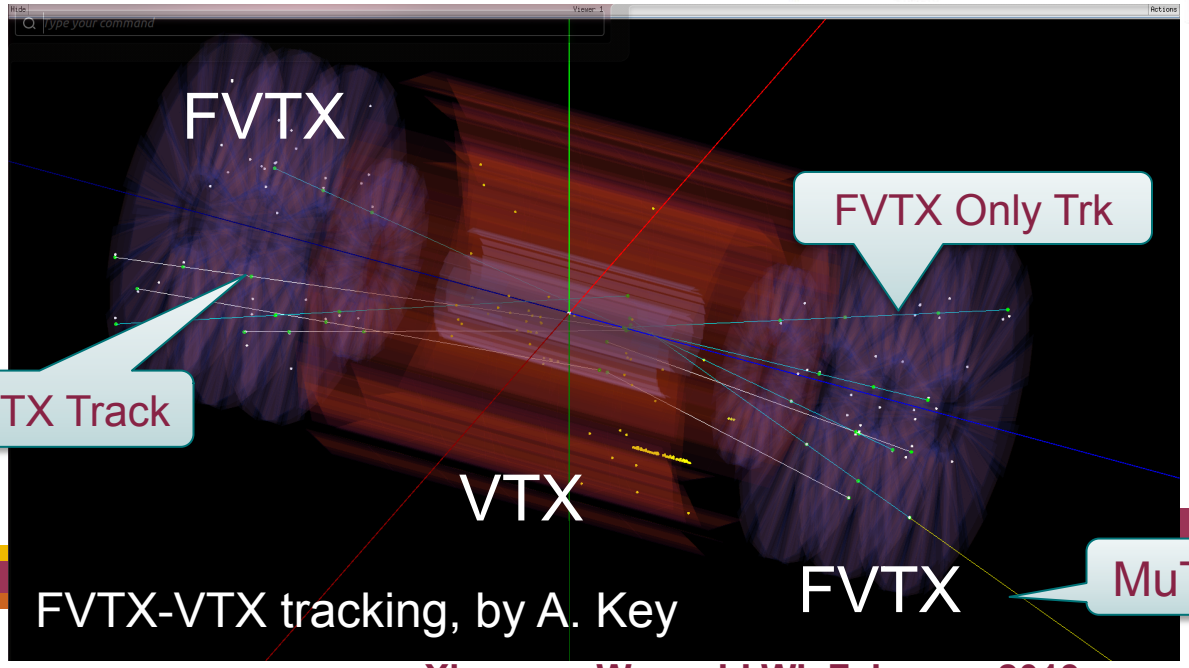


Expected to improve analysis power by

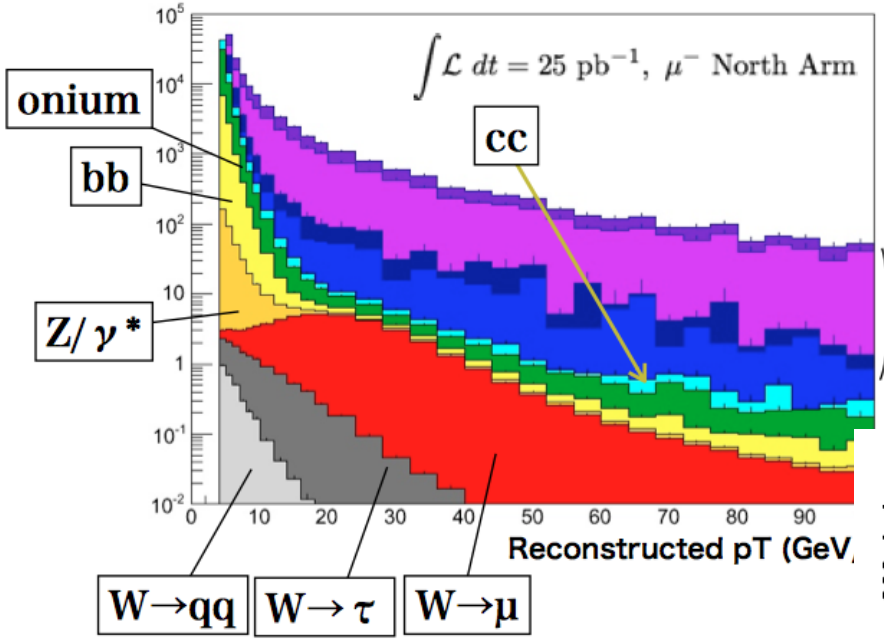
- Precise vertex determination
- Better Tracking

Summary of FVTX Status in 2012

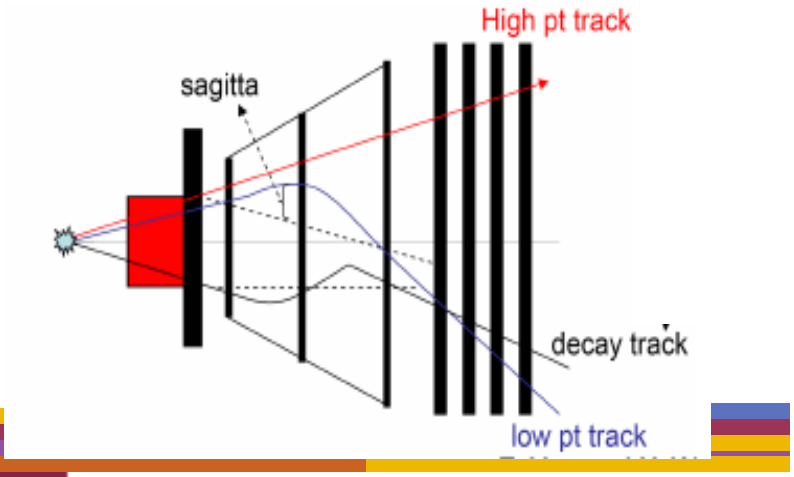
- Over 90% of Detector is operational
- FVTX collected 30pb^{-1} data in pp 500GeV



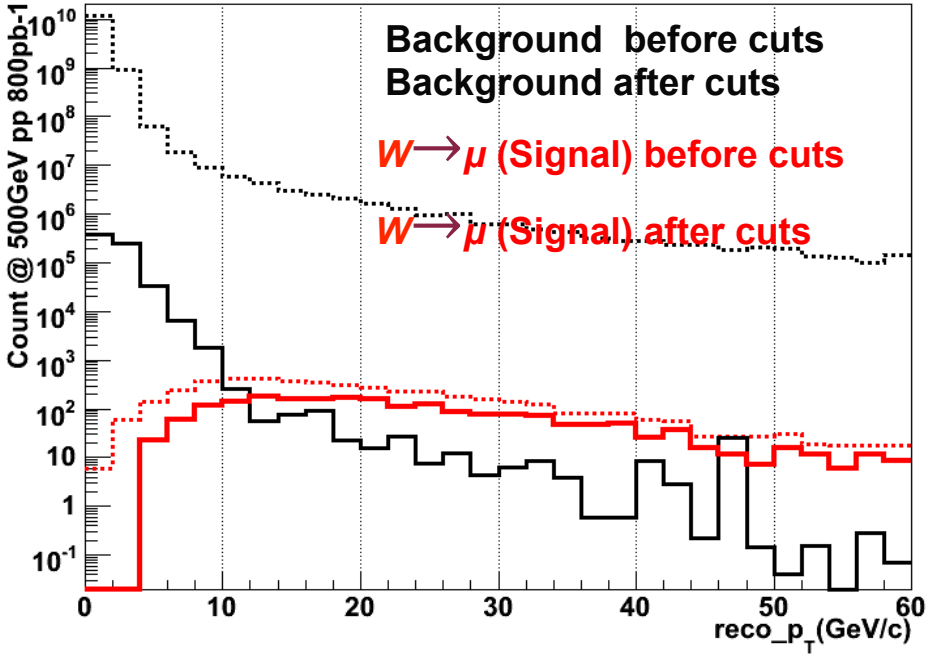
$W^{\pm} \rightarrow \mu^{\pm}$ Background Study



- Dominated background is from misreconstructed low p_T hadrons



Background reduction with FVTX (simulation)



Summary and Outlook

- *W* asymmetry offers a cleaner and more direct probe of sea quark spin.
- PHENIX has measured *W*s at mid and forward rapidities through *W*->*e*(*μ*) decay.
- Run12 p+p 510 GeV run ended successfully. Taking data with VTX, FVTX, and RPC. Analysis is under the way.
- In Run13, an integrated luminosity of 250 pb^{-1} within 30cm vertex range is anticipated with full upgraded hardware set ready.

The V − A interaction of W+ boson couples only the left-handed u quark and the right-handed dbar quark. Then the produced W+ boson is perfectly polarized to the direction of dbar direction. The neutrino from the W+ decay must be left-handed, then the charged lepton prefers to be emitted to dbar direction.

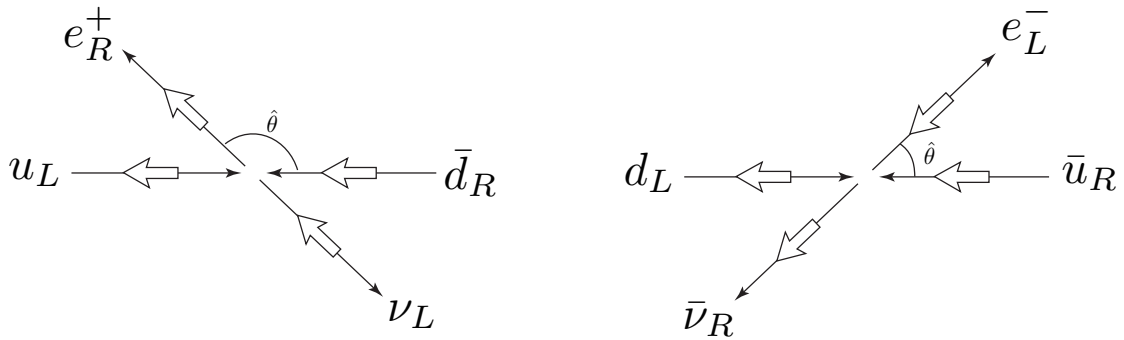


Figure 2.10: Helicity conservation in production and decay of $W^{\pm}$ boson.